Life Cycle Assessment: Introduction and practice in EarthSmart

Instructor's guide SAMPLE

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Part I: Life Cycle thinking

What is Life Cycle thinking, and why is it important?

Error! Reference source not found. displays a representation of the life cycle of a product with its inputs and outputs.

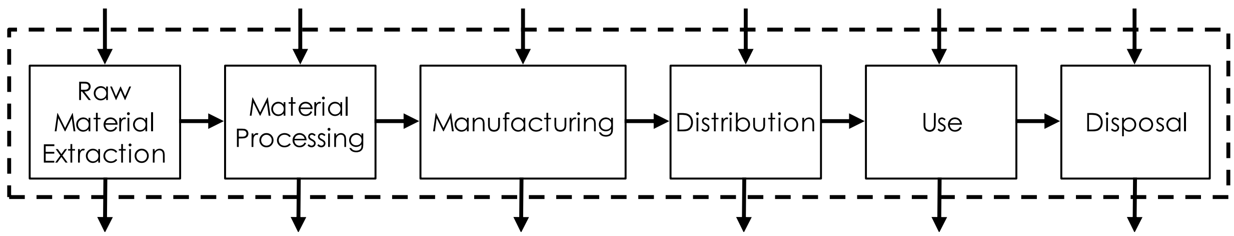

Figure 1. Product life cycle

Each stage converts energy and materials into a part of the product, and in its process it releases some emissions to the air, water, and/or soil. We also see that the life cycle of the product ends at its disposal, thus the energy and resources required to dispose of the product (trash collection, transportation, landfilling) are also attributed to the product.

Life Cycle thinking is the approach of looking at a product's complete life cycle; from the extraction of raw materials, production, all the way to manufacturing, distribution, transportation, use and disposal. Life Cycle thinking tries to capture all the environmental transactions of a product and its materials. These considerations are important to weigh to make better decisions of what goes into the environment and ultimately, us.

To elaborate on the importance of life cycle thinking, recall instances that lacked a life cycle thinking perspective and turned out to be detrimental to communities and the environment. This is a way of learning from the past. Examples go from old to new technologies to carry students from hindsight to thinking about the future proactively. Instructors may add or remove illustrations based on their particular area of expertise such as, agriculture, engineering, electronics, pharmaceuticals, etc.

Current technology: electric cars

Electric cars are often advertised to be “emission free” or “zero emission” because they do not consume gasoline. However, if we examine the life cycle of an electric car, we see that the electricity an electric car consumes may come from fossil fuels depending on the energy mix of the country. Most electric energy in the US comes from coal and natural gas, followed by nuclear energy and renewable sources (eia.gov). Therefore, it is important to know that, although electric cars do not consume liquid fossil fuels through an internal combustion engine, they likely consume coal and natural gas through the local utility's electric plant which brings a different set of emissions. We must recognize these issues to make informed decisions and avoid trading one environmental detriment for another.

> It may be beneficial to share the "The Story of Stuff" video with students to aid in illustrating the general concept.

Alternative materials: bioplastic

Bioplastics are an alternative to petroleum plastics that are derived from vegetable fats. Bioplastics are biodegradable and use less petroleum than traditional plastics. However, there are environmental impacts associated with the production of the source crops. Crops that are grown to produce bioplastics require land and machinery that rely on fossil fuels, water, and fertilizers. Utilizing crops for non-food products at a large scale can also impact food systems. In the case of biofuels, the concept of using a food source as a raw material for an industrial product can raise food prices and cause severe damage to the most vulnerable communities.

For more on the discussion of food versus fuel, see The Guardian article on rising food prices from 2007: https://www.theguardian.com/world/2007/dec/04/china.business.

How do we know if it is worth it to grow crops for plastics or fuel? How do we know if electric cars are better than gasoline cars? And when are they better? It depends. A way to answer these questions is by evaluating the environmental life cycle implications and quantifying them via LCA.

Polychlorinated biphenyls (PCBs)

PCB mass production started in 1935 by the Monsanto Corporation and even though its toxicity was recognized early on, its production was not banned by the US until 1976 – over thirty years later. Even after decades of banning PCBs, the Environmental Protection Agency still runs a program to deal with the remaining effects: https://www.epa.gov/pcbs. PCBs were used as a new cooling and insulating fluid in the electrical industry because it was less flammable than the alternatives at the time.

PCBs are good heat conductors, do not conduct electricity, they are insoluble in water, and they are very stable. However, these same properties meant that PCBs were persistent in the environment and that they would accumulate in animals and humans. PCBs are not soluble in water, but they are in fat. This means they tend to accumulate in the fatty tissues of organisms - therefore the higher up the food chain an animal is, the more PCBs it accumulates. Once in the body, PCBs can be passed to offspring, and can be found in eggs and breast milk. PCBs are highly toxic; exposure to PCBs causes cancer. It also affects the immune and nervous systems and because they act like hormones, they affect the reproductive system.

If we were to take a closer look at the life cycle of PCBs, we would notice that there are severe problems at the manufacturing stage (unsafe working conditions), use phase (exposure to users), and disposal (release into the open environment). Accordingly, the PCB producers could have been more careful about using PCBs to control dust, for instance, and could have taken additional measures to prevent leaking and contamination.

Innovations in the food sector: Cultured meat

Cultured meat is muscle tissue from a cow that is cultivated in a lab and aims to provide a less environmentally harmful alternative to meat. It avoids the need to raise an entire cow and instead, grows the meat tissue directly (the cow is an inefficient intermediary). This form of production is currently being researched and developed.

> This Wikipedia page offers a useful overview of the technology in case students are not familiar with the concept:
>
> https://en.wikipedia.org/wiki/Cultured_meat
>
> After briefly explaining the concept, ask students what could be the life cycle pros and cons to this? Do they think that cultured meat offers a sustainable alternative to meat? Would they eat it?
>
> ***Pros:*** Land use reduction and reduction of agricultural products (pasture) to feed cows. Frees space for agro or forests. No methane emissions from cows. Less or no hormones as used in large scale production. Alternative supply of meat for a growing population.
>
> ***Cons:*** If applied in large scale, it can affect leather and milk production. Currently takes a lot of energy to produce. Possibility of a rebound effect. Consumer perception.

Death Care: Composting

Another example for life cycle thinking can be illustrated with death care, or the treatment of the human remains. Think of death care from a life cycle perspective. What are the implications of burial and cremation?

For burial: There is the use of chemicals to give the body a glow and slow down decomposition. The body is buried in a concrete lined grave in a casket, which uses resources. Also, land use and shrinking space in some metropolitan areas.

For cremation: It is an energy intensive process which is required to convert the body into ashes, ultimately resulting in air emissions.

As a result, some are proposing alternative forms of death care using a more natural approach: https://www.ted.com/talks/katrina_spade_when_i_die_recompose_me#t-765492

The purpose of this example is to get students to apply life cycle thinking to a wide range of human activities and to show how life cycle thinking applies to all human activities.

In class activity for Part I

Select a product and make a schematic of the life cycle (drawing or writing out the steps) from manufacturing to the end of life. For example:

- Milk (growing feedstock, raising cattle, processing, packaging, distribution, transportation, refrigeration, disposal of packaging)
- Wine (vineyard, fermentation, bottling, distribution, disposal)
- A cellphone (mining, processing, manufacturing, distribution, use, disposal)

Activity can be done on the board with everyone discussing and contributing an element to the life cycle or make students do it individually and then share that in class. The goal for this assignment is to get into systems thinking mode and to become aware of all the resources needed for each product.